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HELICOPTER TOW TESTS OF THE U.S. COAST GUARD'S AIR DELIVERY CONTAINER FOR OIL SPILL CONTAINMENT BARRIER

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December 1973

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER NCSL 198-73	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HELICOPTER TOW TESTS OF THE U.S. COAST GUARD's AIR DELIVERY CONTAINER FOR OIL SPILL CONTAINMENT BARRIER		5. TYPE OF REPORT & PERIOD COVERED Informal 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) LCDR John R. Kennedy, USN		8. CONTRACT OR GRANT NUMBER(s) MIPR: Z-70099-4-41543 Task No. 70099
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Coastal Systems Laboratory Panama City, Florida 32401		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Commandant (G-FCP-2/71) U.S. Coast Guard, Washington, D. C. 20590		12. REPORT DATE December 1973 13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Helicopters	Oil Spill
Towing	Environmental Pollution
Tests	Water Pollution
Containment	Simulation
Barriers	

(see reverse side)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

ABSTRACT

An oil spill barrier with its air delivery packing container was successfully towed by a Navy H-53 tow-equipped helicopter. Flight tow tests were conducted to demonstrate feasibility, develop any required special equipment, and provide data for similar Coast Guard tests.

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S/N 0102 014-6601

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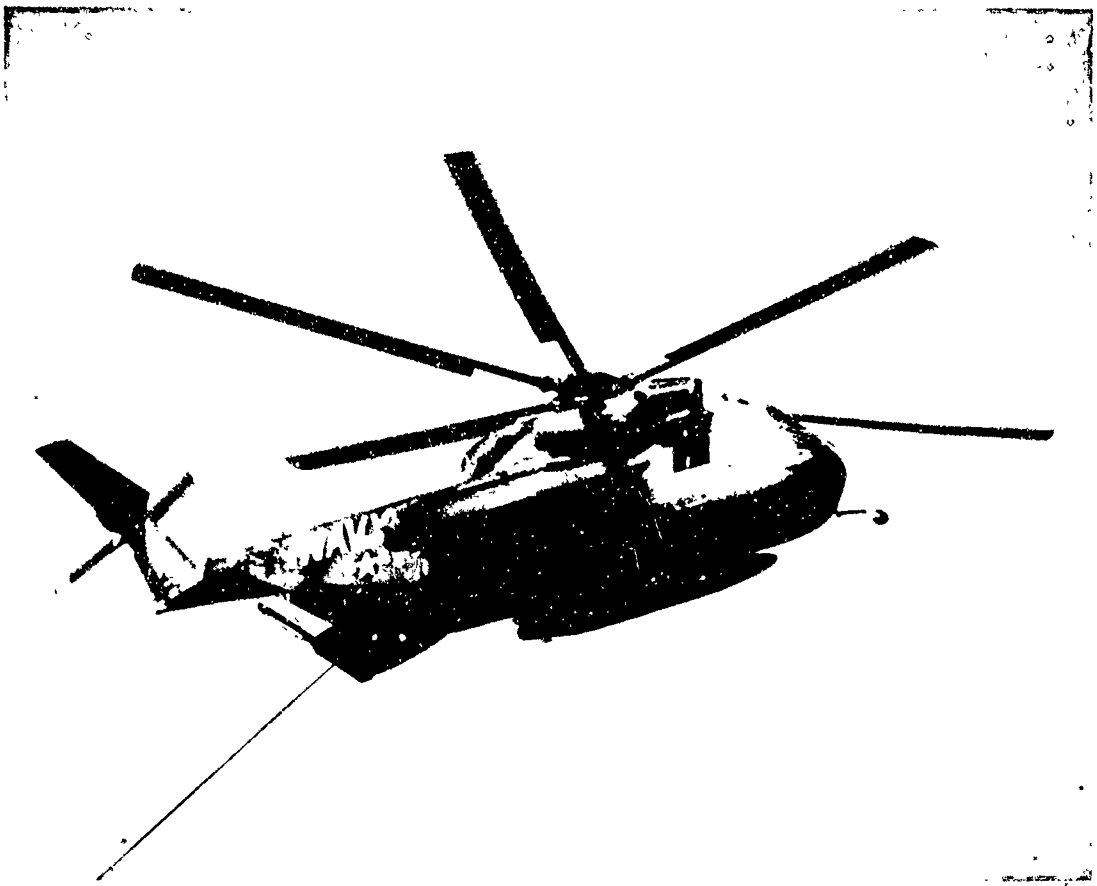
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19. Identifiers

Airborne Towing
ADC (Air Delivery Container)
Air Droppable Container
Oil Spill Barrier
Coast Guard
H-53 Helicopter
HH-3 Helicopter



THE H-53 TOW EQUIPPED HELICOPTER SUCCESSFULLY
TOWED COAST GUARD DEVELOPED OIL SPILL
BARRIER COMPONENTS

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INTRODUCTION

The problems of oil spills at sea and the resulting pollution have been with us for some time and will continue to be a problem. There is no way to eliminate the sources of oil spills such as natural seepage, drilling rigs, subsurface pipelines and storage tanks, tankers, and pumping bilges of other ships.

The U.S. Coast Guard is developing a rapid response system for the containment of oil spills at sea to reduce environmental pollution and allow the recovery of the oil.

This report is limited to Navy H-53 helicopter flight tow tests performed on one segment of the system; i.e., the air-delivery container (ADC) packaging system of the oil containment barrier.

OBJECTIVES

The objectives of the tests performed under MIPR 70099 were fourfold, and included all tasks covered in the statement of work:

1. To determine the feasibility of a helicopter towing the air-delivery container (ADC) containing 612 feet of oil-spill barrier.

2. To design, establish procedures, and test a method of picking up and securing an ADC without surface assistance.

3. To establish a speed versus tension curve for the ADC when towed by a helicopter.

4. Provide recommendations for similar tests using a Coast Guard HH-3 helicopter.

DESCRIPTION

AIR-DELIVERY CONTAINER

The ADC is the package for the U.S. Coast Guard's High Seas Oil Containment Barrier and is basically an aluminum box 9 ft wide by 18 ft long by 5 ft deep. The ADC with the barrier will not weigh more than 18,000 pounds. The dimensions allow two ADC's to be transported by C-130 aircraft and dropped by parachute.

OIL SPILL BARRIER

The barrier is a device designed for containment of oil on the surface of water and consists essentially of a flexible fence to keep the oil on one side. The barrier is 61[illegible] feet long in three spliced sections with 130 feet of extension line on each end. The barrier is folded accordian fashion for packing in the ADC. When deployed the barrier is held in palce by the tension lines attached to mooring buoys and supported by floats which inflate as the barrier is extracted from the ADC. The tension line side faces upcurrent or upwind for proper orientation of the barrier when collecting oil.

ADC BALLAST WEIGHTS

For test purposes 17 rectangular sections of steel plate were bolted to the inside bottom of the ADC to simulate the weight of the oil spill barrier. The ballast weights were fabricated to prevent damage to the barrier in earlier air drop tests and were used in the first two helicopter tow tests for the same reason. The design criteria for the ballast weights did not include waterborne considerations and as a result the ADC with ballast weights has much more free surface available (allowing water to slosh around inside) than when the oil spill barrier is installed.

FLIGHT TESTS

The ADC with a ballast load to simulate the oil spill barrier was towed in the Gulf of Mexico at Panama City on 17 and 19 October 1973. The ADC with the oil spill barrier inside was towed on 14 November 1973 outside Mobile Bay.

FLIGHT TEST ONE

The first tow test flight (ADC with ballast load) was made on 17 October 1973. The ADC was boat-towed into position to simulate air drop from a C-130. The retrival system described in detail in Appendix A was placed into the water and deployed. Figures 1 and 2 show deployment of the system. Three unassisted surface pickups of the tow rig were accomplished using the procedures listed in Appendix B. All pickups were successful and the only problem encountered was a large static electrical shock from the grappling hook which was present even when the helo rescue hoist cable was lowered into the water for a grounding line.

The tow line was a 400-foot section of braided polypropylene line with a design break strength of 10,500 pounds and a yield strength of 4200 pounds. The ADC floated with the bow down and almost awash (Figures 1, 3, and 4). Tow of the ADC was very unstable. Figure 5 shows classic vortex shedding. This vortex shedding resulted in relatively large tension surges, tow cable whipping, and unstable skew angle (skew angle being the angle the tow cable makes with the helicopter longitudinal centerline). While highly objectionable, behavior was within the tow limits of the H-53 and the run was completed on a 1-mile range delineated by high intensity narrow beam New Zealand lights. An average speed of 3.75 knots with a tow tension of 2500 ($\pm$ 1500) pounds was established. The test was terminated when the tow line failed on the second run. It should be noted that: (a) during the 3.75-kt average run some 3000-pound surges occurred, (b) when the tow line failed an attempt was being made to attain 5 knots, (c) the cockpit tensiometers are deliberately damped so that a spike load will not actuate the automatic release and the pilots can read the cockpit tensiometer, and (d) on the final flight, Flight Test Three, the vortex shedding phenomena was absent and therefore was caused by either the free surface available inside the ADC with ballast weights installed, different cg location, different wind/sea conditions or some combination of the three.

FLIGHT TEST TWO

The second flight test was made on 19 October and was intended to test suggested methods of improving tow stability. The ADC had a ballast load. The following changes were made and tested:

1. The tow bridle legs were shortened as much as possible so that the tow was essentially single point from the front.

2. The tow bridle legs were lenghtened to 25 feet to increase the moment arm when the ADC yawed.

3. To tow from the Holland coupler located on an aft corner of the ADC--this resulted in essentially an uneven length bow.

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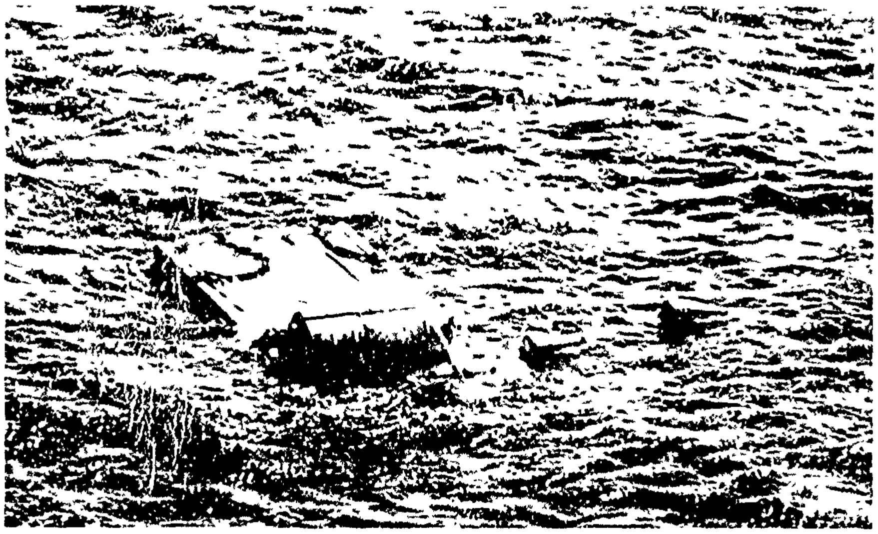

FIGURE 1. SALTWATER ACTUATED BUOY DEPLOYMENT

FIGURE 2. SEPARATION BY WIND AND WAVE ACTION
(HELICOPTER SUPPLIED WIND IF NECESSARY)

FIGURE 3. RETRIEVAL RIG JUST PRIOR TO PICKUP BY HELO

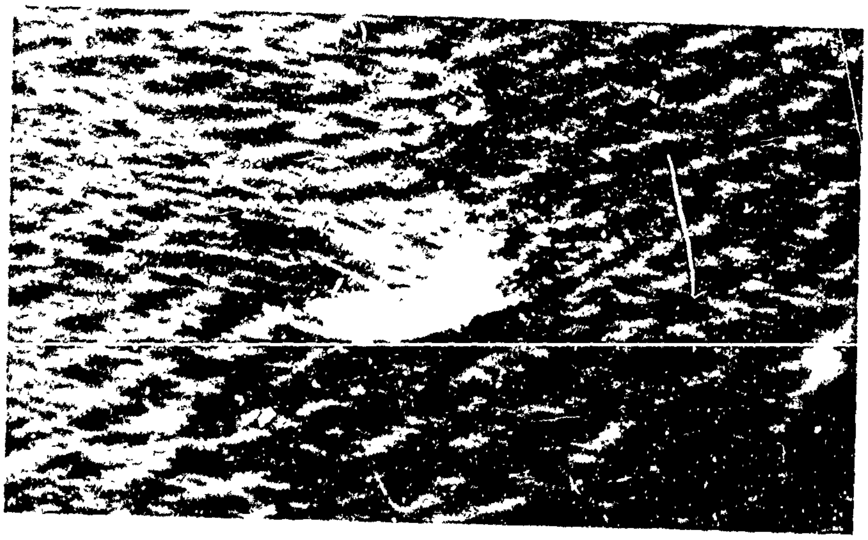

FIGURE 4. ADC WITH BALLAST WEIGHTS UNDER TOW, SLACK IN TOW LINE ADC YAWING AND ALMOST AWASH

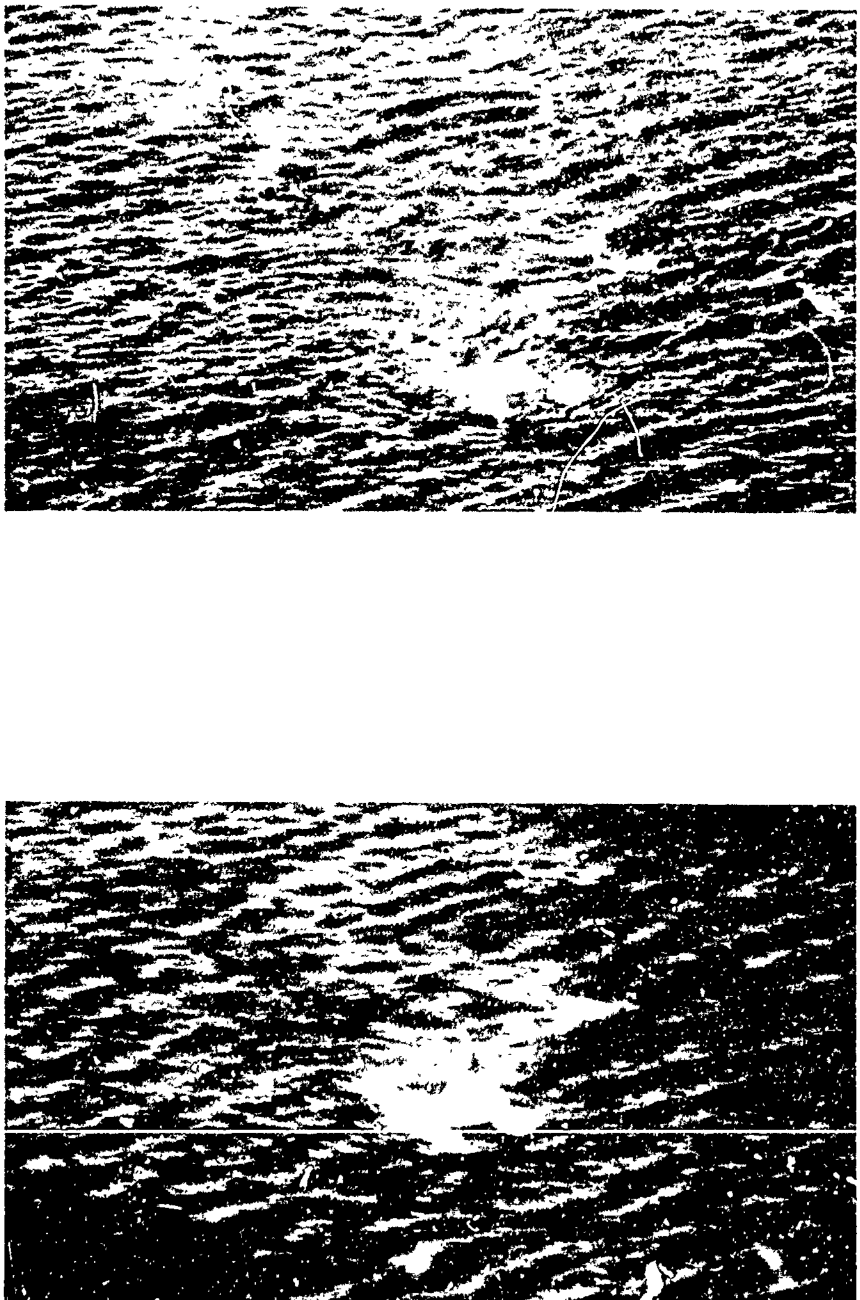

FIGURE 5. ADC WITH BALLAST WEIGHTS UNDER TOW, VORTEX SHEDDING PATTERN IN THE WATER

4. Change tow line to 750 feet of 7/16 inch wire rope for additional strength. (Break strength 16,300 pounds and yield strength 9600 pounds).

The ADC was still unstable in tow. The increased bridle length (2) did improve the stability while changes (1) and (3) aggravated the instability. The speed versus tension curve (Figure A4 of Appendix A) was constructed from data taken from flight tow tests when the tow bridle legs were lenghtened (2).

FLIGHT TEST THREE

The third test flight was made with the ADC loaded with oil spill barrier on 14 November 1973 and was part of a full systems test for the ADC and oil spill barrier.

This test differed in two ways from the two previous tow tests: (a) the oil spill barrier was packaged in the ADC rather than using ballast, and (b) the tow line was changed back to braided polypropylene and the length increased from 400 feet to 800 feet in an effort to improve the tow characteristics through increased shock absorpsion in the line.

The full systems test was conducted in accordance with *Test Plan for the High Seas Oil Containment Barrier System* by the Environmental and Transportation Technology Division, U.S. Coast Guard, Office of Research and Development, 30 October 1973.

Once under tow it was immediately obvious that there was substantial improvement in tow characteristics. The ADC now floated bow high with 4 to 6 inches of freeboard, tension surges were reduced to $\pm$ 500 pounds, and a mean tension of 1000 pounds was held while towing the ADC. After securing one end of the oil containment barrier to a mooring buoy, the ADC was towed as the barrier was deploying. This portion of the test was the most difficult due to the low tension desired (500 pounds) and the fact that reliable tension and skew cannot be read in the cockpit below 600 pounds. (Essentially the pilot must take his instructions from the crew chief stationed in the aft compartment.) Tension during the extraction phase reached 1500 pounds at one time and resulted in substantially faster deployment of the oil spill barrier than was planned for. The low tension specified for extraction was a precautionary measure; in fact the upper limit of barrier extraction speed has not been established.

The only problem that occurred was that the tow line fouled on the mooring buoy and required some extra maneuvering to free it before the oil spill barrier extraction or deployment could begin.

RESULTS AND CONCLUSIONS

1. Helicopter towing of the ADC is feasible with the advantage of reduced response time, and independance from surface vessels.

2. Pick-up of an ADC tow rig without surface assistance was successfully accomplished.

3. The ballasted ADC did not successfully simulate the tow characteristics of the ADC with the oil spill barrier when towed by a helicopter. Consequently the speed-tension curve of Figure A4 is not representative of these parameters for the ADC with the oil spill barrier in place. Therefore, it is concluded that further tow tests of the ballasted ADC by a helicopter with less tow capabilities than a tow-equipped H-53 should not be attempted.

4. The most probable cause of the vortex shedding and instability exhibited by the ADC with ballast weights is the free surface available.

5. Towing an ADC with the oil spill barrier installed by a helicopter with less capabilities than an H-53 cannot be recommended at this time due to insufficient flight test data.

RECOMMENDATIONS

1. Perform additional testing to determine the cause of the vortex shedding and instability exhibited in Flight Tests One and Two or verify that the instability does not exist when the ADC contains the oil spill barrier. This must include environmental conditions other than calm seas and zero wind.

2. Towing with a boom-equipped (internal tow point) HH-3 could be very useful in towing small boats and is so recommended; and, after completion of recommendation one has a good chance of being able to tow an ADC with the oil spill barrier installed.

3. The Coast Guard HH-3 helicopter should not attempt to tow the ballasted ADC.

Note: The Coast Guard has told the author that it has study results that indicate the feasibility of the HH-3 as a tow vehicle and are continuing efforts in this direction both inhouse and with contractors.

4. Prior to attempting Coast Guard helicopter tow operations, a Coast Guard aircrew should be trained in tow operations by Naval Coastal Systems Laboratory or by Helicopter minecountermeasure Squadron Twelve. One of the following should be accomplished:

a. Procure tow-equipped helicopters.

b. Modify present CG helos in inventory to be tow-capable so that the load axis goes through the center of gravity to avoid control reversal problems that can be encountered when towing from the cargo hook of a single rotor helicopter.

c. Severely limit tow tension from a cargo hook type tow and ensure that the aircrew are aware of what can result if those limits are exceeded.

Of the three possibilities for a tow capability, limited tow tension (c) appears to offer the cheapest and fastest method of obtaining this capability. However, it is not recommended because it does limit the tow capability and is the most likely to result in fatal accidents from inadvertant overtension and improper response, or mechanical failure/aircraft systems emergency.

5. The aircrewman handling the grappling hook for a surface unassisted pickup (Appendix B) should be issued and required to wear heavy rubber gloves.

6. If the Coast Guard desires an interim heavy tow capability, an interservice agreement should be established between the U.S. Coast Guard and the U.S. Navy, where services by CH-53 tow helicopters are provided by Naval Coastal Systems Laboratory or Helicopter Mine Countermeasure Squadron Twelve, on a prearranged, "as-required" basis.

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APPENDIX A

HARDWARE AND EQUIPMENT FOR ADC TOW

MK 1 Mod 0 Tow Line, Drawing Number 07070-11314. The tow line assembly consists of a 5/8-inch diameter nylon polypropylene rope, 800 feet long, with closed sockets potted at each end, one 4-inch diameter aluminum tow ball and one 1/2-inch screw pin anchor shackle. The tow ball is secured to one of the closed sockets to make connection with tow helicopter. The 1/2-inch screw pin anchor shackle is used to connect the eye of the other closed socket to the ADC bridle. The rated breaking strength of the tow line is 10,500 pounds with an elastic limit of 4,200 pounds. The yield strength of the eye on the closed socket is 10,000 pounds with a safe working load of 5,000 pounds.

Grappling Hook/Recovery Line. The recovery line used by the helicopter crew to retrieve the tow line consists of 150 feet of 3/8-inch diameter polypropylene rope, 5 feet of 1/4-inch proof coil chain, one standard 4-pound grapnel, and shackles to connect parts into one unit. The chain is connected, with shackles, to the eye of grapnel, and then the rope is secured to other end of chain. This adds weight and stability to the hook for dragging through water.

Tow Line Packaging/ADC. The frame to contain the MK 1 Mod 0 tow line was constructed from 1/4-inch thick aluminum sheet (Figure A-1). The tow bridle was brought into the frame and secured with 50-pound break marlin ties. Then the tow line was stacked from bottom to top, securing each lay with 20-pound break ties. The forward end of the tow line extended outside of the frame and was secured to the end of the line from the recovery buoy package. Finally, a canvas cover was secured to the front of the frame to prevent premature deployment of the tow line.

Water Actuated Recovery Buoy Package. This system consists of two flotation markers, Air Cruisers Company part number 3800, two water actuated electronic/battery packs, 2 MK 21 explosive drivers, 2 explosive driver holders, one 100-foot section of 1/4-inch diameter polypropylene rope, one 25-foot section of 1/4-inch diameter polypropylene rope, and one styrofoam package.

The buoy package is secured to the starboard front side of the ADC right beside the tow line package, with the water switches facing forward.

When the ADC is air-dropped to the water, the buoys will be inflated and will drift away from the ADC. Wind or wave action will cause the 100-foot section of line from the tow line and the buoys to stretch out. Then the two buoys will be separated by the 25-foot section of line. The system is shown in Figures A-2 and A-3.

Speed/Tension Curve for the ADC. Four runs were made through the New Zealand lights and this resulted in only 2 points on the curve. The device was not stable enough for a 4,000 pound run because of the location of the dummy load in the ADC. The forward end of the ADC was awash causing gyrations and high tension surges. Figure A-4 gives the resulting curve.

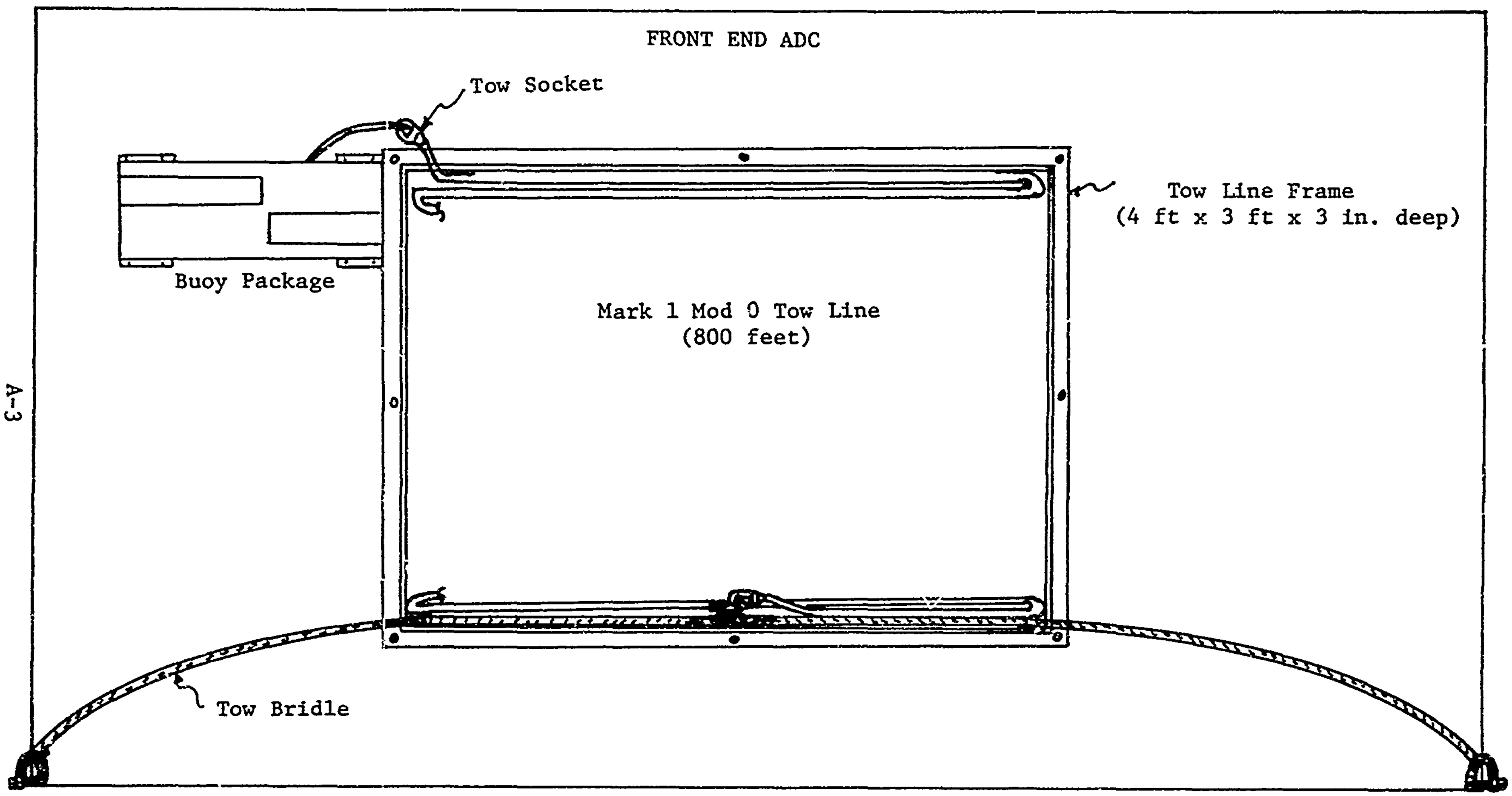
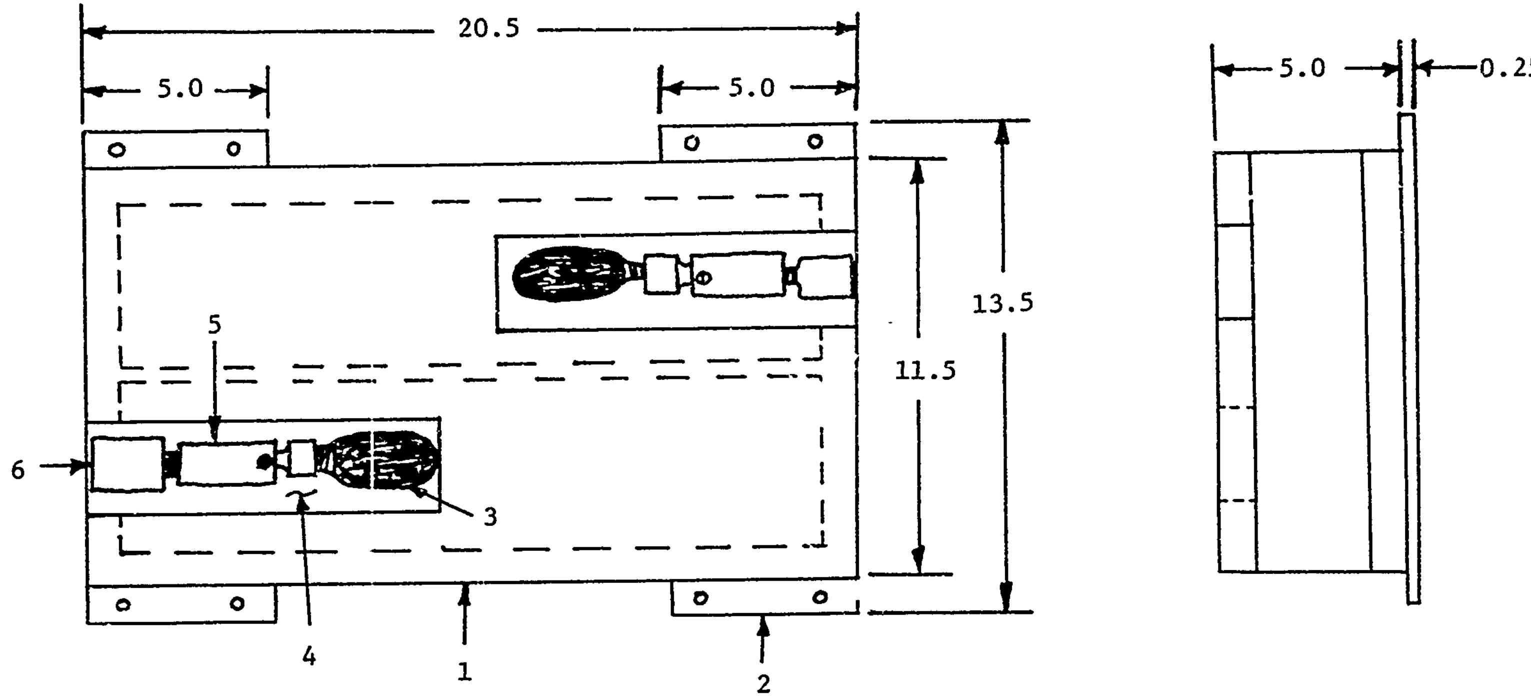
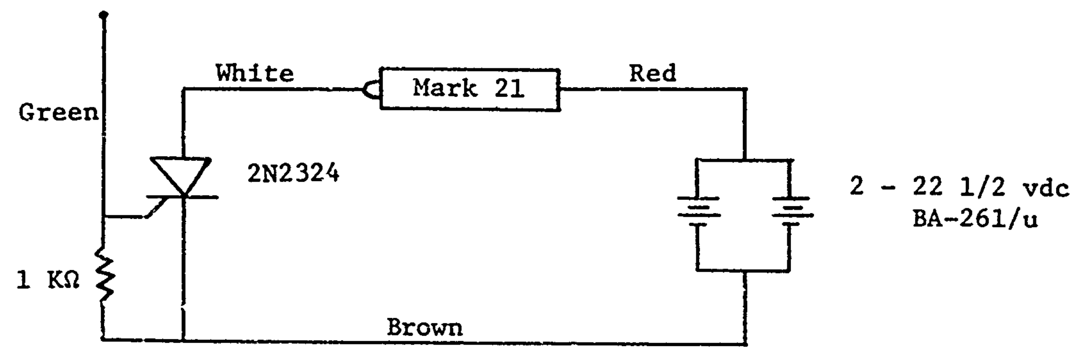


FIGURE A1. AIR PICKUP SYSTEM

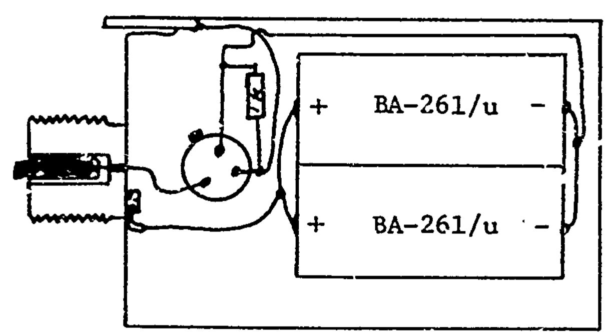


Part No.	Part	No. Req'd.
6	Battery Pack	2
5	Mark 21 Holder	2
4	Flotation Marker	2
3	CO_2 Cylinder	2
2	Phenolic Mount	2
1	Styrofoam Package	1

FIGURE A2. RECOVERY BUOY



Schematic



Water Actuated Electronic/Battery Pack

FIGURE A3. ELECTRONIC BATTERY PACK

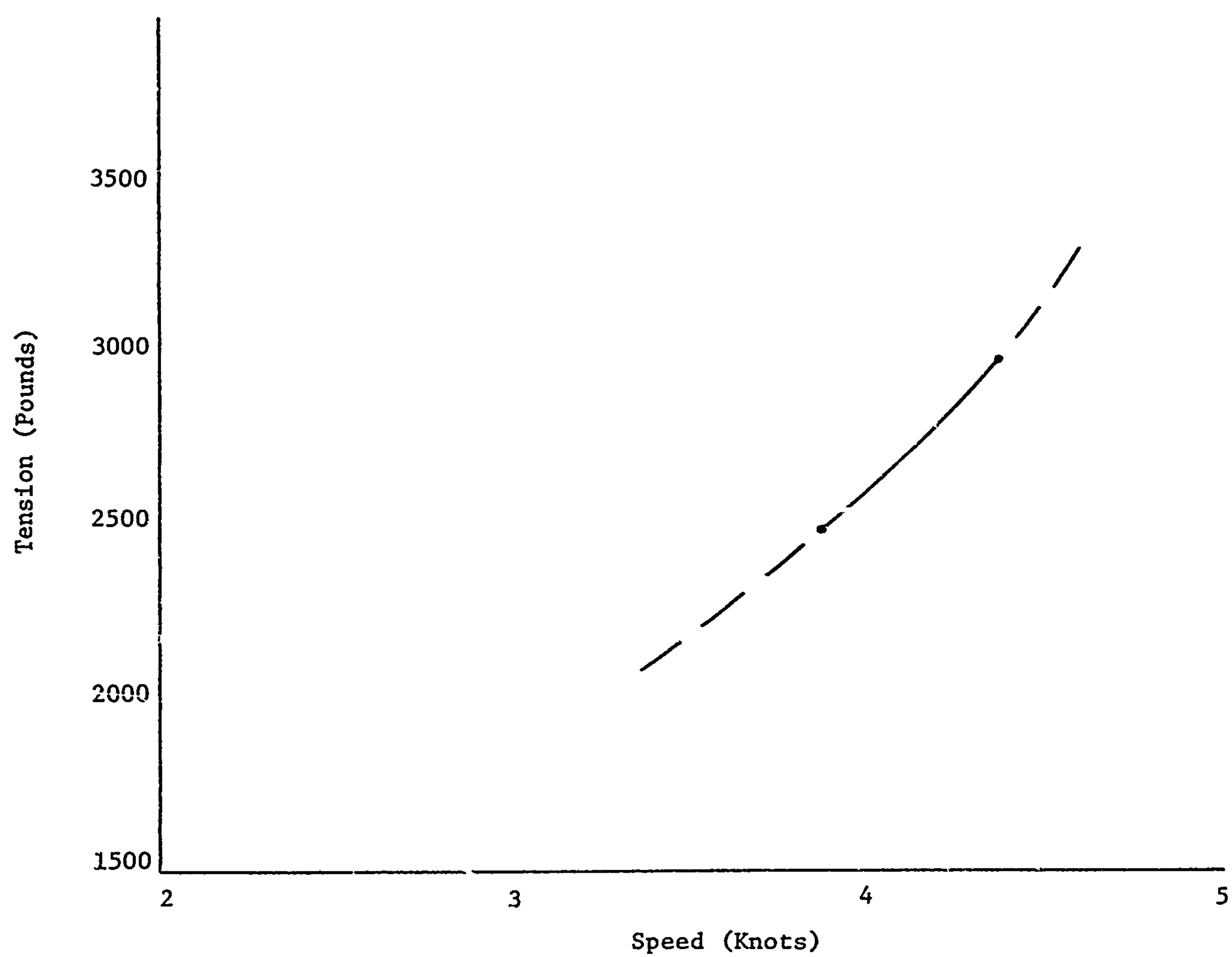


FIGURE A4. SPEED/TENSION CURVE OF BALLASTED ADC TOW

APPENDIX B

AIRBORNE CREW PROCEDURES FOR TOW LINE PICKUP WITHOUT SURFACE ASSISTANCE

After arrival on the scene, the pilot flys the helicopter into a hover at 100 feet of altitude in a position where the crewman located in the aft cabin by the ramp has visual contact with the inflated saltwater activated buoys.

The following instructions will be followed:

WARNING

Crewman shall be secured to the helicopter by use of a standard gunners belt.

1. Pilot or crewman lower rescue hoist cable into water to provide grounding of the electrical potential generated by the rotor system.

NOTE

Prior to takeoff, the electrical continuity between the helicopter and rescue cable should be checked.

2. Crewman lower ramp to level position and direct pilot to position the helicopter so that the ramp is directly over the saltwater actuated buoys.

3. Crewman lower grappling hook and engage leader line between the two saltwater actuated buoys.

4. Retrieve grappling hook with leader line into helicopter, pulling all slack into helicopter - report to pilots "leader is in."

5. Continue to pull on leader, retrieve polypropylene tow line into the helicopter report "tow line aboard".

6. Place tow ball into place on end fitting of tow line.

7. Seat tow ball into hook in accordance with NATOPS and remove leader, take position forward of the dam and then report "tow ball seated, ready for tow".

8. Provide skew directions to pilots until cockpit indicator for skew and tension become effective.